Amendments to the Claims

Please amend Claims 1-7, 9-15, 17, 21-26, 28, 29, 31 and 33-39. The Claim Listing below will replace all prior versions of the claims in the application:

Claim Listing

1. (Currently amended) A system for balancing state of charge among a string of plural series connected electrical energy storage units, comprising:

a string of electrical energy storage units, each storage unit having a state of charge;

a circuit configured to selectively ~~monitoring~~ monitor the state of charge of each storage unit at least when a storage unit is being charged or discharged,~~;~~ and to transfer energy from a selected storage unit to the string of storage units when the state of charge of the ~~a~~ selected storage unit is greater than a target state of charge~~, the circuit transferring energy from the selected unit to the string of storage units, such that~~ to converge the state of charge of the selected storage unit ~~converges~~ toward the target state of charge.

2. (Currently amended) The system of claim 1 wherein:

the circuit is further configured to transfer energy from the string of storage units to the selected storage unit when the state of charge of the selected storage unit is less than the target state of charge~~, the circuit transferring energy from the string of storage units to the selected unit, such that~~ to converge the state of charge of the selected storage unit ~~converges~~ toward the target state of charge.

3. (Currently amended) The system of claim 1, wherein the circuit comprises:

a power converter configured to transfer energy from the selected storage unit to charge the string of units when the state of charge of the selected storage unit is greater than the target state of charge, and to transfer energy from the string of units to charge the

selected storage unit when the state of charge of the selected storage unit is less than the target state of charge.

~~the power converter transferring energy from the selected unit to charge the string of units when the state of charge of the selected unit is greater than the target state of charge; and~~

~~the power converter transferring energy from the string of units to charge the selected unit when the state of charge of the selected unit is less than the target state of charge.~~

4. (Currently amended) The system of claim 3, wherein the power converter comprises:

an up converter configured to transfer ~~transferring~~ energy from the selected unit to charge the string of units; ~~and~~ or

a down converter configured to transfer ~~transferring~~ energy from the string of units to charge the selected unit.

5. (Currently amended) The system of claim 3, wherein the power converter is bidirectional and comprises:

a common transformer that is used ~~as a~~ in down ~~converter~~ conversion to transfer energy from the string of units to charge the selected unit when the state of charge of the selected unit is less than the target state of charge~~;~~, and in up conversion ~~the common transformer that is used as an up converter~~ to transfer energy from the selected unit to the string of units when the state of charge of the selected unit is greater than the target state of charge.

6. (Currently amended) The system of claim 3, wherein the circuit further comprises:

plural semiconductor switches selectively coupling the power converter to the selected storage unit.

7. (Currently amended) The system of claim 6, wherein:

the plural semiconductor switches are bidirectional and are configured to couple the power converter to the selected storage unit to discharge the storage unit when the state of charge of the selected storage unit is greater than the target state of charge, and to charge the storage unit when the state of charge of the selected storage unit is less than the target state of charge.;

~~when the state of charge of the selected unit is greater than the target state of charge, a pair of the plural bidirectional switches electrically coupling the power converter to the selected unit to discharge the unit; and~~

~~when the state of charge of the selected unit is less than the target state of charge, the pair of the plural bidirectional switches electrically coupling the power converter to the selected unit to charge the unit.~~

8. (Original) The system of claim 7, further comprising:

a polarity selector connecting the pair of plural bidirectional switches to the power converter.

9. (Currently amended) The system of claim 6, wherein:

the plural semiconductor switches are unidirectional;

~~when the state of charge of the selected unit is greater than the target state of charge,~~ a first pair of the plural unidirectional switches configured to couple ~~electrically couples~~ the power converter to the selected storage unit to discharge the storage unit when the state of charge of the selected storage unit is greater than the target state of charge; and

~~when the state of charge of the selected unit is less than the target state of charge,~~ a second pair of the plural unidirectional switches configured to couple ~~electrically couples~~ the power converter to the selected unit to charge the unit when the state of charge of the selected storage unit is less than the target state of charge.

10. (Currently amended) The system of claim 3, wherein the circuit further comprises:

a controller selectively monitoring the state of charge of each storage unit; and

the controller configured to direct ~~directing~~ the power converter to transfer energy between the selected storage unit and the string of storage units, such that the state of charge of the selected storage unit converges toward the target state of charge.

11. (Currently amended) The system of claim 10, wherein the circuit further comprises:

a first sensor configured to detect ~~detecting~~ voltage and current data of the selected storage unit; and

the controller configured to utilize ~~utilizing~~ the voltage and current data from the first sensor to monitor the state of charge of the selected storage unit.

12. (Currently amended) The system of claim 10, wherein the circuit further comprises:

a second sensor configured to detect ~~detecting~~ total current data of the string of storage units;

the controller configured to utilize ~~utilizing~~ the total current data from the second sensor to determine the target state of charge.

13. (Currently amended) The system of claim 1, further comprising:

plural strings of electrical storage units coupled in series, each storage unit having a state of charge;

corresponding circuits configured to selectively monitor ~~selectively monitoring~~ the state of charge of each storage unit in a corresponding string of electrical storage units and, for each of the plural strings of storage units, configured to transfer energy between a selected storage unit and the corresponding string of storage units when the state of charge of the selected storage unit is different than a target state of charge to converge the state of charge of the selected storage unit toward the target state of charge.; ~~and~~

~~for each of the plural strings of units, when the state of charge of a selected unit is different than a target state of charge, the corresponding circuit transferring energy between the selected unit and the corresponding string of units, such that the state of charge of the selected unit converges toward the target state of charge.~~

14. (Currently amended) The system of claim 13, further comprising:

a master controller;

for each of the plural strings of storage units, the master controller configured to determine ~~determining~~ a corresponding target state of charge;

the master controller configured to direct ~~directing~~ each of the corresponding circuits in transferring energy between a selected storage unit and the corresponding string of storage units to converge~~, such that~~ the state of charge of the selected storage unit ~~converges~~ toward the corresponding target state of charge.

15. (Currently amended) The system of claim 14, wherein each of the corresponding circuits comprises:

a power converter;

the power converter configured to transfer ~~transferring~~ energy from the selected storage unit to charge the corresponding string of units when the state of charge of the selected storage unit is greater than the corresponding target state of charge; and

the power converter configured to transfer ~~transferring~~ energy from the corresponding string of storage units to charge the selected storage unit when the state of charge of the selected storage unit is less than the corresponding target state of charge.

16. (Original) The system of claim 15, wherein each of the corresponding circuits comprises:

plural semiconductor switches selectively coupling the power converter to each storage unit.

17. (Currently amended) The system of claim 13, further comprising:

a master controller configured to determine ~~determining~~ a common target state of charge;

the master controller configured to direct ~~directing~~ each of the corresponding circuits in transferring energy between a selected storage unit and the corresponding string of storage units, such that the state of charge of the selected storage unit converges toward the common target state of charge.

18. (Original) The system of claim 1, wherein each storage unit is a storage cell.

19. (Original) The system of claim 1, wherein each storage unit is a battery module having a string of cells.

20. (Original) The system of claim 1, wherein a battery pack comprises a string of one or more storage units.

21. (Currently amended) The system of claim 1, wherein the string of storage units are in a battery module, there being plural battery modules forming a battery pack.

22. (Currently amended) A system for balancing state of charge among plural series connected electrical energy storage units, comprising:

a string of electrical energy storage units, each storage unit having a state of charge;

a circuit configured to selectively monitor ~~monitoring~~ the state of charge of each storage unit at least when a storage unit is being charged or discharged, and to transfer energy from a selected storage unit to a non-dissipative load~~; and~~ when the state of charge of a selected storage unit is greater than a target state of charge~~, the circuit transferring energy from the selected unit to a non-dissipative load, such that~~ to converge the state of charge of the selected storage unit ~~converges~~ toward the target state of charge.

23. (Currently amended) The system of claim 22 wherein:

the circuit is further configured to transfer energy from the non-dissipative load to the selected storage unit when the state of charge of the selected unit is less than the target state of charge~~, the circuit transferring energy from the non-dissipative load to the selected unit, such that~~ to converge the state of charge of the selected storage unit ~~converges~~ toward the target state of charge.

24. (Currently amended) A system for balancing state of charge among plural series connected electrical energy storage units, comprising:

a string of electrical energy storage units, each storage unit having a state of charge;

a circuit configured to selectively monitor ~~monitoring~~ the state of charge of each storage unit at least when a storage unit is being charged or discharged ~~under a load~~, and to transfer energy between the selected storage unit and the string of storage units~~; and~~ when the state of charge of a selected unit is different than a target state of charge, ~~the circuit transferring energy between the selected unit and the string of storage units, such that~~ to converge the state of charge of the selected storage unit converges toward the target state of charge.

25. (Currently amended) A method for balancing state of charge among plural series connected electrical energy storage units, comprising:

selectively monitoring the state of charge of each storage unit in a string of electrical energy storage units at least when a storage unit is being charged or discharged;

when the state of charge of a selected storage unit is greater than a target state of charge, transferring energy from the selected storage unit to the string of storage units, such that the state of charge of the selected storage unit converges toward the target state of charge.

26. (Currently amended) The method of claim 25, further comprising:

when the state of charge of the selected storage unit is less than the target state of charge, transferring energy from the string of units to charge the selected unit, such that the state of charge of the selected unit converges toward the target state of charge.

27. (Original) The method of claim 26, wherein the energy is transferred by a power converter.

28. (Currently amended) The method of claim 27, further comprising:

selectively coupling the selected storage unit to the power converter by enabling a pair of plural semiconductor switches.

29. (Currently amended) The method of claim 28, wherein the plural semiconductor switches are bidirectional and comprising:

when the state of charge of the selected storage unit is greater than the target state of charge, enabling a pair of the plural bidirectional switches to electrically couple the power converter to the selected storage unit to discharge the storage unit; and

when the state of charge of the selected storage unit is less than the target state of charge, enabling the pair of the plural bidirectional switches to electrically couple the power converter to the selected storage unit to charge the storage unit.

30. (Original) The method of claim 29, further comprising:

connecting the pair of plural bidirectional switches to the power converter through a polarity selector.

31. (Currently amended) The method of claim 28, wherein the plural semiconductor switches are unidirectional and comprising:

when the state of charge of the selected storage unit is greater than the target state of charge, enabling a first pair of the plural unidirectional switches to electrically couple the power converter to the selected storage unit to discharge the storage unit; and

when the state of charge of the selected storage unit is less than the target state of charge, enabling a second pair of the plural unidirectional switches to electrically couple the power converter to the selected storage unit to charge the storage unit.

32. (Original) The method of claim 25, further comprising:

detecting voltage and current data of the selected storage unit; and

utilizing the voltage and current data to monitor the state of charge of the selected unit.

33. (Currently amended) The method of claim 25, further comprising:

detecting total current data of the string of storage units; and

utilizing the total current data to determine the target state of charge.

34. (Currently amended) The method of claim 25, wherein plural strings of electrical storage units are coupled in series, each storage unit ~~have~~ having a state of charge, and further comprising:

selectively monitoring the state of charge of each storage unit in a corresponding string of electrical storage units; and

for each of the plural strings of storage units, when the state of charge of a selected storage unit is different than a target state of charge, transferring energy between the selected storage unit and the corresponding string of storage units, such that the state of charge of the selected storage unit converges toward the target state of charge.

35. (Currently amended) The method of claim 34, further comprising:

for each of the plural strings of storage units, determining a corresponding target state of charge; and

transferring energy between the selected storage unit and the corresponding string of units, such that the state of charge of the selected storage unit converges toward the corresponding target state of charge.

36. (Currently amended) The method of claim 34, further comprising:

determining a common target state of charge; and

transferring energy between the selected storage unit and the corresponding string of storage units, such that the state of charge of the selected storage unit converges toward the common target state of charge.

37. (Currently amended) A method for balancing state of charge among plural series connected electrical energy storage units, comprising:

selectively monitoring the state of charge of each storage unit in a string of electrical energy storage units at least when a storage unit is being charged or discharged; and

when the state of charge of a selected storage unit is greater than a target state of charge, transferring energy from the selected storage unit to a non-dissipative load, such that the state of charge of the selected storage unit converges toward the target state of charge.

38. (Currently amended) The method of claim 37, further comprising:

when the state of charge of the selected storage unit is less than the target state of charge, transferring energy from the non-dissipative load to the selected storage unit, such that the state of charge of the selected storage unit converges toward the target state of charge.

39. (Currently amended) A method for balancing state of charge among a string of plural series connected electrical energy storage units, comprising:

selectively monitoring the state of charge of each storage unit in a string of electrical energy storage units, the selected storage unit being monitored ~~under a load~~ at least when a storage unit is being charged or discharged;

when the state of charge of a selected storage unit is different than a target state of charge, transferring energy between the selected storage unit and the string of storage units, such that the state of charge of the selected storage unit converges toward the target state of charge.